



Meteorology: An Educator's Resource for Inquiry-Based Learning for Grades 5-9



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How to Use This Guide

Meteorology: An Educator's Resource for Inquiry-Based Learning for Grades 5-9 is written as a supplement to existing Earth and space science curricula for grades 5-9. The guide may be used in both formal and informal educational settings as well as at home. It should be used in conjunction with lectures, discussions, textbooks and other teaching material. This guide is not intended to be a complete course in meteorology; rather, its function is to assist educators in instilling excitement in learning about meteorology by permitting the learner to take increasing responsibility for his/her learning. The learner should experience “how we arrive at what we know,” rather than memorizing what we know. This publication was developed to enhance the understanding of inquiry-based learning from the educator/teacher's perspective as well as from the learner's perspective. Inquiry-based learning has many levels. In general, inexperienced learners and younger learners will require more guidance than more-experienced and older learners who are better equipped to take responsibility for their learning. There are four levels of inquiry defined in this publication, confirmation-verification, structured inquiry, guided inquiry and open inquiry. The levels will be further defined and explained in the introductory chapter.

The guide is structured to include a short review of some principles of meteorology and facts so that they may be readily available to the educator. The Weather and Climate chapter (Chapter 2) is not intended to be used as an all-inclusive textbook, but rather an educator's guide to some of the phenomena explored in this publication. Many activities offered in this guide build upon each other and use the inquiry in the previous activity to assist in the activity that follows. Thus, this publication enhances the understanding of meteorology by beginning with basic and essential parameters of weather and then moving through mind-engaging interactions with complex meteorological systems. The “Think About This!,” “Probing Further,” and “Examining Results” sections are provided as examples to the educators; they may be used to stimulate the students to organize their thoughts in a particular direction. Educators may use their own creativity in stimulating student inquiry. Further educator information concerning these sections can be found in Appendix I: Suggestions For Maximizing The Use of Learner-Designed Activities.

The learner is encouraged to build and/or test a variety of weather instruments to better understand the basic factors involved in weather phenomena. The weather instruments are then brought together to form a weather station. Collecting weather information combined with existing information about cloud systems allows the learner to apply the knowledge to predict weather systems. Supplementary information and activities, which are not inquiry-based, but deemed useful by the authors, are included in the appendices, including career information Web sites in Appendix V.

An interactive video game, entitled “The Hurricane Hunters,” is the second part of this project. Nightlight Studios and the authors of this guide developed the game, which should be the culminating experience in learning about meteorology as the learner has the opportunity to better understand the dynamics of hurricanes.

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Chapter 1. Introduction

An Historical Look

Meteorology is one of the oldest observational sciences in human history and perhaps the most relevant to a broad segment of society. Some of our first observational meteorologists and weather forecasters were shepherds, farmers and sailors whose livelihoods and safety depended upon understanding and predicting the weather.



Shepherds guarding their flocks on the ancient hill-sides looked skyward for signs of changes in the weather. Farmers noticed that rain or drought could destroy crops if they were planted or harvested at the wrong time. Sailors experienced severe storms at sea or long delays if they were “trapped” in areas of calm. These groups gathered data through keen observations, which proved important as a foundational database of weather information.



The following are old adages that relate to weather changes:

- Red sky at night, sailors’ delight.
- Red sky in morning, sailors take warning.
- Aches in bones and joints indicate changes in the weather.



- Wind that causes leaves to turn upward on trees indicates the coming of weather changes.
- Lack of dew on the grass in early morning indicates changing weather.
- A circle around the moon indicates impending precipitation.

Can these adages be explained scientifically? Can they become crude weather predictors? Perhaps after an in-depth examination of some of the weather activities included in this booklet, these statements can be reexamined. Additional weather adages may be added to this list. See Appendices II and V for more adages. Ask your students to think of others.

Questions for the Students: Can you think of ways that weather changes affect activities and events in modern society? Do you think weather has important consequences for most people in modern society? Why? Why not?

Equipment and Supplies Necessary To Conduct the Activities

We understand that many schools may not have the supplies and equipment necessary to conduct costly meteorology experiments and activities, so this publication focuses on activities using common materials people can find in the home or in local stores. It is important to note that we have included only one way to construct instruments; the educator may have alternative methods, which may work as efficiently and are less costly. The authors make these instrument construction suggestions as a starting point for educators. Staff members who work in well-equipped schools may substitute commercially available equipment and supplies. However, there are pedagogical advantages to constructing the equipment. Constructing the equipment may lead to a better understanding of the phenomenon measured and how the equipment works. The “Materials Needed” suggestions are based on the activity; quantities required would depend upon how the students are grouped for conducting activities.

It is extremely important that teachers advise students about safety considerations when conducting science activities. Educators must exert judgment as to the maturity level required for the students to carry out some of the activities independently. As an example, can the students, wearing protective heatproof gloves and safety glasses, handle the boiling water, or should the educator handle the water with the students at a safe distance? The same question applies to the sling psychrometer, Are the students mature enough to sling the psychrometer, or should the educator sling it at a safe distance from the students?



Development of the Learning Philosophy to Science Education

For science education to have meaning for all students, there should be a strong focus on the essential elements of inquiry learning, which are described in the National Science Education Standards (NSES) and the American Association for the Advancement of Science (AAAS) Benchmarks. Using these documents as a foundation, the Council of State Science Supervisors (CS3), through the CS3/NASA NLIST Initiative, developed an operational definition of Science as Inquiry (www.nlistinquiryscience.com).

The operational definition of science as inquiry promulgated by the CS3/NASA NLIST Initiative consists of these essential elements: (1) conceptual context for science content; (2) relevant and important science content; (3) information-processing skills; and (4) the scientific habits of mind (approaches). These essential elements should become the focus of material development. They enhance the relevancy and applicability of science knowledge.

- Learning set in a broad context (concepts) can enable deeper understanding and enhance the transfer of knowledge to new and different situations (Appendix III).
- Content then becomes a building block for constructing and comprehending important concepts.
- Skill development becomes the means for continuing the generation of new knowledge.
- Habits of mind (approaches) employed by experts and nurtured in learners can ensure the integrity of the discipline and provide a valid world view from the perspective of science (Appendix III).

These essential elements, brought together holistically in a learning environment, make science both relevant and applicable for all learners. Furthermore, this approach enables the development of skills and approaches needed to continue lifelong learning.

The skills scientists use and the scientific approach, which are the foundation of generating a body of scientific knowledge, are often overlooked in science education. Science education is still taught and learned as a history lesson—with a focus on “this is what we know.” If educators emphasize “how we know,” students will develop skills and acquire scientific attitudes that yield a valid scientific view of the world and the ability to use these skills as a life-long way of resolving problems. Many activities used to teach science are mindless “hands on” lessons and do not engage a “minds on” response. Capable students can see the activity outcomes without going through the procedures and are not challenged. Many educators think inquiry learning takes place only through student activities. Teacher demonstrations, classroom discussions, and even lectures can encourage the development of the essential elements of inquiry if the focus is on “how we come about knowing” rather than on “this is what we know.”

Scientists approach the generation of knowledge differently than the way schools provide learners access to this knowledge. Experts start with observations, pose questions, and at some point frame a context for these questions. Depending upon the discipline, they apply the ground rules or approaches to a particular discipline. Experts make “wrong turns” or reach “dead ends” and often must rework approaches to get resolutions to questions. Using these skills and applying the ground rules of the discipline enables experts to improve the learners’ abilities to resolve problems. With this emphasis on learning, the student develops a more valid view of the scientific process and can better see the world through the lens of a particular discipline.

AN IMPORTANT NOTE: For teachers who need a more traditional correlation with the national standards and benchmarks that put greater emphasis upon content correlation, see Appendix IV. This type of correlation does not negate the important educational approach outlined previously but helps to illustrate that this publication’s approach considers the demands on teachers in current classrooms.

Levels of Inquiry in Activities

Just as children move through a series of stages when learning to walk, programs designed for science education should consider important developmental stages in moving learners toward taking charge of their own learning. The programs should have effective experiences that will enable learners to move from receivers of information to pursuers of knowledge. Young learners and less-experienced learners need more direction and “hand holding,” but as they mature and increase their abilities, they need more sophisticated challenges. There should be a gradual shift in the help given students as they move to the upper levels of schooling, even during the later stages in a course.



There are four levels of activities that can be classified according to levels of inquiry potential. While any of these inquiry levels can be appropriate for all levels of learners, it is expected that the more-structured learning experiences lie at lower grade levels and the more open-ended and less-structured ones predominate as students approach high school graduation. The following classification is modified from the work of Herron (1971) and his efforts to develop a simple, practical rubric for assessing the degree to which activities promote student inquiry. Based partly on the writings of Schwab (1964), Herron describes four levels of inquiry. The subsequent classification is a slight modification in looking at a teacher-centered approach versus a shift toward a more learner-centered approach.



Throughout this publication the learner will have the opportunity to experience activities that represent each of the four levels. Furthermore, these activities will be specifically identified as to the predominant inquiry level of the particular activity. This identification will assist the educator in better understanding inquiry levels and how to select or develop more activities that address these various inquiry levels.

(1) Confirmation-verification. Students confirm or verify a concept through both a prescribed question and procedure; the results are known in advance. The value of this level of activity is in introducing students, who have had very little or no experience in performing science activities, to the general steps in the design of investigations.

(2) Structured inquiry. Students investigate a teacher-presented testable question through a prescribed procedure. The results of the investigation are not known in advance, and students generalize relationships by using the outcomes of the activity. The value of this level of activity is to challenge the learner to examine the data and to come to a valid conclusion based upon these data. It also gives the learner further experience with the concept of a “testable” question and investigative design structure.

(3) Guided inquiry. Students investigate a teacher-presented question using their own procedures for conducting the activity. The value of this level of activity is in challenging learners to design the procedure that will produce appropriate data to validly resolve the question. Further, the learner has an additional opportunity to learn from the teacher-presented testable question.

(4) Open inquiry. Students investigate a topic-related question that they have formulated. They are responsible for defining a manageable question(s), designing procedures to collect, record, and evaluate data, and draw interpretations, inferences, and conclusions. In this level of activity, the student benefits from learning how to design a testable question and also to design a procedure to generate the data necessary to appropriately resolve the question. The teacher ensures that the student addresses the concepts being studied by framing a context in a broad nontestable statement, such as, “Investigate an aspect about what causes air movement within Earth’s atmosphere.” It is then necessary for the learner to carve out a piece or pieces of this statement that can be tested.

NOTE: It should be understood that any of these inquiry levels of activities can provide educational benefit. However, it is important to challenge the learner to take more responsibility for his/her learning. After working through these activities with students, the teacher will also have a better understanding of ways to modify these levels of activities to suit the needs of various learners.